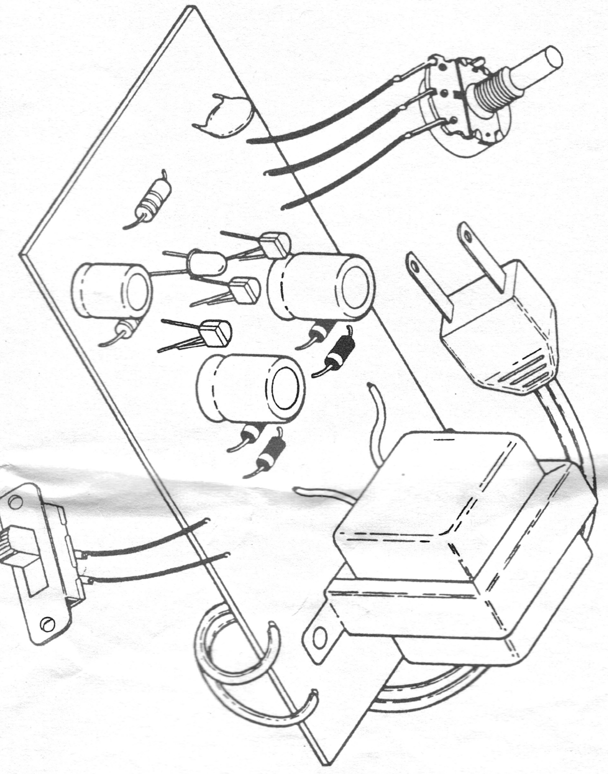
828

PARTS KIT

1028

BUILD A 0 TO 9-VOLT VARIABLE POWER SUPPLY

For radios, cassette players etc.



- Step By Step Construction Diagram
- Troubleshooting Guide
- Theory of Operation
- Pencil Exercises

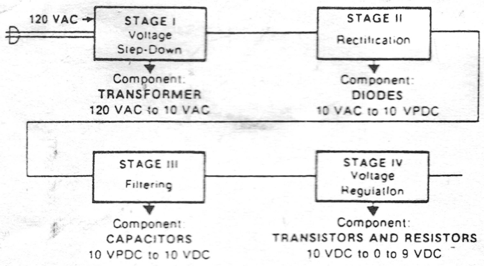
Electronic Koursewsare Interactive

CIRCUIT OPERATION

Now that you have the 0 to 9 Volt Variable Power Supply built and functioning correctly, let's take a look at how it works.

A power supply is a device that changes AC (Alternating Current), to DC (Direct Current). At your wall socket is 120 volts at 60 cycles per second - AC. A power supply like the one you have just built, will take that 120 volts AC, and through a series of steps or stages, alter it to produce a steady DC at the voltage desired.

There are basically four stages to a power supply - each on containing a particular component, designed to do its part to bring the AC at 120 volts down to DC at (in this case) 0 to 9 volts. The block diagram for each stage, along with a brief explanation of its function, is shown below; review it carefully.



STAGE 1- Takes the 120 volts AC from the wall socket and converts it to 10 volts AC. The component used to accomplish this is a transformer.

STAGE 2- Takes the 10 volts AC and converts it to PDC (Pulsating Direct Current). The voltage is now 10 volts PDC. This is not a smooth DC, but it is DC. The components used to accomplish this are diodes.

STAGE 3 - Takes the 10 volts PDC, and through a "filtering" action, converts it to a smooth DC. The component used to accomplish this is a capacitor.

STAGE 4- Provides a variable output voltage from 0 to 9 volts. A voltage divider and three transistors are used to accomplish this.

Let's now look at each stage a bit more closely.

PENCIL EXERCISE 1

1- There are four stages to our basic power supply, each one doing its part to convert the ________________ volts AC from the wall socket to ____________ DC.

2- Stage 1 uses a _____________ to step-down 120 volts AC to 10 volts AC.

3- Stage 2 uses _____________ to convert AC to PDC.

4- Stage 3 uses _____________ to filter or smooth out the PDC.

5- Stage 4 uses a _______________ and ______________ to vary the output voltage and current

STAGE 1 - VOLTAGE STEP -DOWN COMPONENT: TRANSFORMER

A transformer is an electrical component that, through magnetic induction, transfers electrical energy from one circuit to another. In the process it will usually step up or down the incoming voltage (Fig. A) . In our project the 120 volts AC (from the wall socket) is reduced to 10 volts AC . This step -down in voltage occurs because the secondary coil has fewer turns than the primary coil - here approximately one turn in the secondary for ten turns in the primary. Remember, the output at this point is still AC.

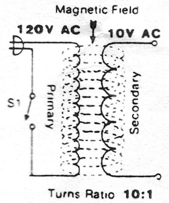


Fig A

PENCIL EXERCISE 2

1- A transformer is an electrical component that, through ____________, transfers electrical energy from one circuit to another.

2- In our power supply the transformer is used to step ___________ the incoming voltage.

3- In a step-down transformer the secondary coil has ___________ turns than the primary coil.

STAGE 2 - RECTIFICATION COMPONENT: DIODE

A diode is an electrical one-way gate. It allows current to pass through it in one direction only, and thus aids in converting AC to DC.

In its construction, a diode is a two element device. One element is known as the cathode, the other element the anode (Fig. B).

If the cathode is negative with respect to the anode, the diode will conduct or pass current as shown in Fig. C.

If the cathode is positive with respect to the anode, the diode will not conduct current as shown in Fig. D.

By placing four diodes in the form of a bridge, we can convert the 10 volts AC from the secondary coil of our step-down transformer to 10 volts PDC.(Pulsating Direct Current) . The result is known as full-wave rectification; and here is how it works:

During the positive half-cycle of AC the top of the transformer secondary is positive and the botton half is negative, (Fig. E). With this condition, current flows through the diodes D1 and D3 and the output resistor R1 is shown.

During the negative half cycle of AC, the top of the transformer secondary is negative and the bottom is positive (Fig. F). With this condition, current flows through diodes D4 and D2 and the output resistor R1. Note that in both half cycles of AC, current flows in the same direction, through the ouput resistor. Thus we have changed AC to DC - a pulsating DC to be sure, but DC nevertheless.

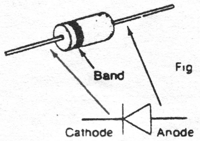


Fig B

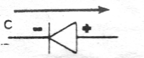


Fig. C Direction of Current Flow

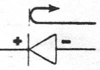


Fig D No Current Flow

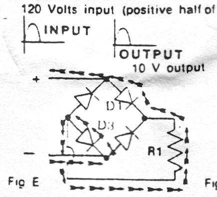


Fig E

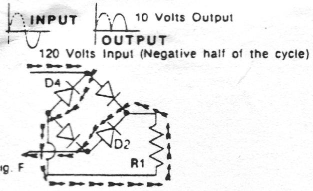


Fig. F

PENCIL EXERCISE 3

1- A diode conducts current when its cathode is ______________ and its anode is ______________.

2- In our power supply ______________ diodes are formed into a bridge to change AC to PDC.

3- During any one half-cycle of AC current flows through only ____________ of the four diodes.

STAGE 3 FILTERING COMPONENTS: CAPACITOR

A capacitor is an electrical component that stores electrical energy. It consists of two metal plates separated by an insulator, (Fig. G) The amount of charge (electrical energy) a capacitor can hold is know as its capacitance and is measured in farads. Most capacitors used in power supplies, however, are rated in microfarads which means millionth of a farad. Typical values would be 1,000 to 4,000 uF (microfarads). A capacitor is uesd in a power supply to filter or smooth out the rough PDC coming from the rectifiers (Diodes). We get smooth DC by "filling in" the "valleys" between the PDC, (Fig. H).

As current travels toward output resistor R1, some of it is diverted to the lower plate of filter capacitor C1, (Fig. I) . This occurs on the rising portion of the PDC cycle. On the descending portion, C1 discharges its load of electrons through R1. This has the effect of filling in the "valleys" of the PDC, and is known as filtering. The result is a smooth DC, (Fig. H).

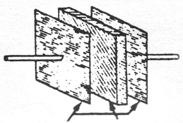


Fig. G

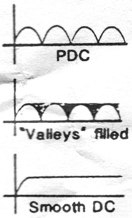


Fig. H

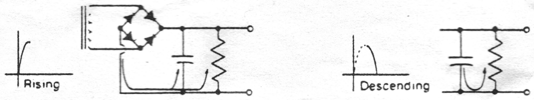


Fig. I

PENCIL EXERCISE 4

1- Most filter capacitors are measured in ________________.

2- A capacitor is used as a filter by filling in the "____________".

3- The capacitor stores energy on the ____________ portion of the PDC, and discharges it through R1 on the ______________ portion of the PDC.

STAGE 4 - VOLTAGE CONTROL COMPONENTS:RESISTORS AND TRANSISTORS

The 828, 0 to 9 Volts Variable Power Supply produces a variable output from 0 to 9 Volts.

To accomplish this, a strengthened (reinforced) Darlington pair plus a voltage divider are used.

With transistors Q1, Q2, and Q3 arranged in what we call a Strengthened Darlington Pair, we use a small amount of voltage to control a large amount of current (Fig. J).

When the base (B) of Q1, receives a positive voltage of sufficient strength, the transistor allows a large current to flow through its emitter-collector (E-C) circuit. With that large current now flowing through Q2 and Q3's emitter-base (E-B) circuit, they too turn on. Note that Q2 and Q3 are arranged in parallel). And the current flowing through the emitter-collector (EC) of Q2 plus the current flowing through EC of Q3 is much greater than that flowing through Q1. We have a relatively small voltage controlling a large current.

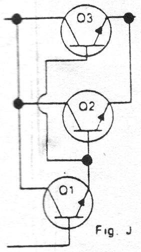


Fig. J

ELECTRONIC KITS INTERNATIONAL, INC.

828

0 TO 9 VOLT VARIABLE POWER SUPPLY

PROJECT DESCRIPTION

This handy and low cost variable power supply is designed to supply an output voltage from 0 to 9 volts DC to a host of electronics devices such as: transistors radios, portable tape recorders, electronic games, protoboard experiments, burglar alarms, etc. and it can also be used to charge 9 volt batteries.
Output current is 75 mA at 9 volts and 200 mA at 6 volts or less.
The 828 is a very reliable variable power supply, that will give you many years of good service.

STEP BY STEP IN MOUNTING THE COMPONENTS

( ) STEP 1

Important information to help in successful kit building
1- Check off each step as you go.
2- Use the best quality soldering iron you can, maximum of 60 watts.
3- Pick up the circuit board and look at both sides, notice one side has metal traces, the other does not. All electronic parts in this kit will be mounted on the side that does not have metal traces.

( ) STEP 2

Identify D1, D2, D3, and D4, the 1N4003 diodes. Bend leads at right angles and mount them to the PC board with the band at one end in the correct direction, as shown in the pictorial diagram. Bend leads slightly, solder and cut off excess leads.

( ) STEP 3

Identify R1, the 330 ohms resistors (Orange, Orange, Brown, Gold) and R3, the 6.8 K ohm resistor (Blue, Grey, Red, Gold). Bend leads at right angles and mount them to the PC board as shown in the pictorial diagram. Bend leads slightly, solder and cut off excess leads.

( ) STEP 4

Identify Q1, Q2, and Q3, the three transistors 2N3904. Mount them to the PC board with the flat side in the correct direction, as shown in the pictorial diagram. Leave about 1/8 to-1/4 inch between the body of the transistor and the surface of the PC board. Solder and cut off excess leads.

( ) STEP 5

Identify C1 and C2, the 1000uF capacitor and C3, the 220 uF capacitor. Mount them to the PC board. These capacitors have polarity, therefore be sure the negative and positive leads are positioned exactly as shown in the pictorial diagram (probably, these capacitors only will be marked either the negative or the positive lead). Bend leads slightly, solder and cut off excess leads.

( ) STEP 6

Identify C4, the 1 uF capacitor (this capacitor may be marked: .1, 104, or 104Z). Mount it to the PC board as shown in the pictorial diagram. Bend leads slightly , solder, and cut off excess leads.

( ) STEP 7

Identify D5, the LED (red light emitting diode). Find the flat side of its body. Mount it to the PC board with the flat side in the correct direction, as shown in the pictorial diagram. Leave about 1/2 inch between the body of the LED and the surface of the PC board. Solder and cut off excess leads.

( ) STEP 8

Identify R2, the 50K ohm potentiometer. Solder wires to R2 as shown in the pictorial diagram and then solder the other end of these wires to the circuit board.

( ) STEP 9

Identify S1, the switch. Solder two wires to its leads and then solder the other end of these wires to the PC board, as shown in the pictorial diagram.

( ) STEP 10

Identify T1, the transformer. Solder the two wires from the 9 volts side, to the PC board, as shown in the pictorial diagram, and then solder the two wires from the 117 V side. Bolt the transformer to the PC board using the nuts and the bolts provided.

( ) STEP 11

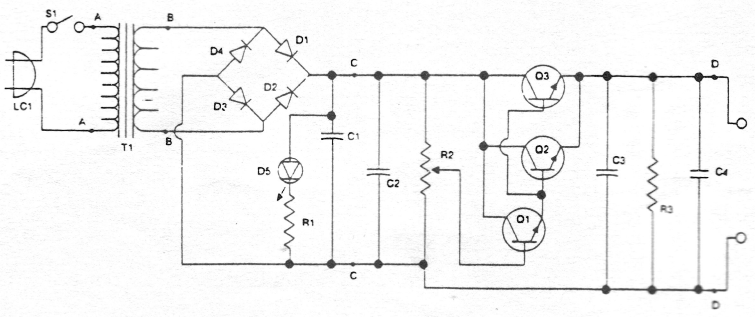
Identify LC1. the AC line cord. Strip the ends of LC1 and insert them in the PC board. Solder carefully avoiding solder bridges between the connections.

( ) STEP 12

Identify the red and black wires. Solder them to the PC board, as shown in the pictorial diagram.

PARTS LIST & SCHEMATIC DIAGRAM

T1 - 117-9 Volt (100mA) transformer
S1- Switch, SPST
LC1- AC line cord
D1 - D4 - 1N4003 Diode
D5 - LED
R1- 330 ohm Resistor
R2- 50K ohm Potentiometer
R3- 6.8K ohm Resistor
C1- C2 - 1000 uF / 16 V Capacitor
C3 - 220 uF / 16 V Capacitor
C4- .1 uF Capacitor
Q1, Q2, Q3- 2N3904 Transistor



As the transistors Q2 and Q3 are arranged in parallel, if the output current of the power supply is 100mA, through the E-C circuit of Q2 will flow 50 mA and through the E-C circuit of Q3 will flow 50 mA too. If we would have, only Q1 and Q2 as Darlington Pair's transistors, and if our output current would be 100 mA, through the E-C circuit of Q2 would flow all the output current (100 mA). That is why, we call to our special Darlington Pair, with three transistors, Strengthened or Reinforced Darlington pair.

The amount of voltage applied to Q1's base is controlled by the voltage divider network consisting of R2. Notice that this voltage divider is placed across C1 and C2 which are at 10 volts DC. To understand how a voltage divider works we must review the concept of voltage drop.

When a load (resistor) is placed across a voltage source (AC or DC) the entire source voltage will be used up or "dropped" across the load. This is true regardless of the value of the load resistor (Fig. K). In both circuits shown, a 100 volt drop occurs across R1.

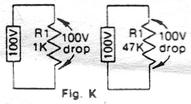


Fig. K

If two resistors are placed in series (voltage divider) across a voltage source, together they will use up or "drop" the entire source voltage. How much voltage each resistor will drop depends on its value relative to the other resistor. If both resistors are of equal value, they will drop an equal amount of voltage (Fig. L). If they are of a different value, they will drop a portion of the source voltage, depending of their resistance. The higher the resistance, the more voltage will be dropped (Fig. M).

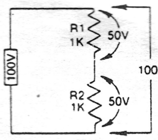


Fig. L

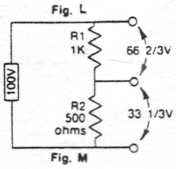


Fig. M

In our circuit, the voltage divider is a potentiometer (R2). As R2 is rotated in one direction, the resistance at B increases, while the resistance at A decreases. As the resistance at B increases so does the voltage drop across it. Therefore, the voltage on the base of Q1 also goes up, Fig. N. This in turn, will effect the amount of current flowing in the emitter-collector circuit of Q2 and Q3 and the output voltage.

TROUBLESHOOTING INSTRUCTIONS

STEP 1. Checking The PC Board For Breaks.
If you are using a PC Board other than the supplied by EKI, make absoutely sure there are no breaks in the copper traces. Examine each trace carefully, loking for tiny "hairline" cracks that indicate a break in the continuity. Often times these breaks can be repaired simply by bridging them with solder.

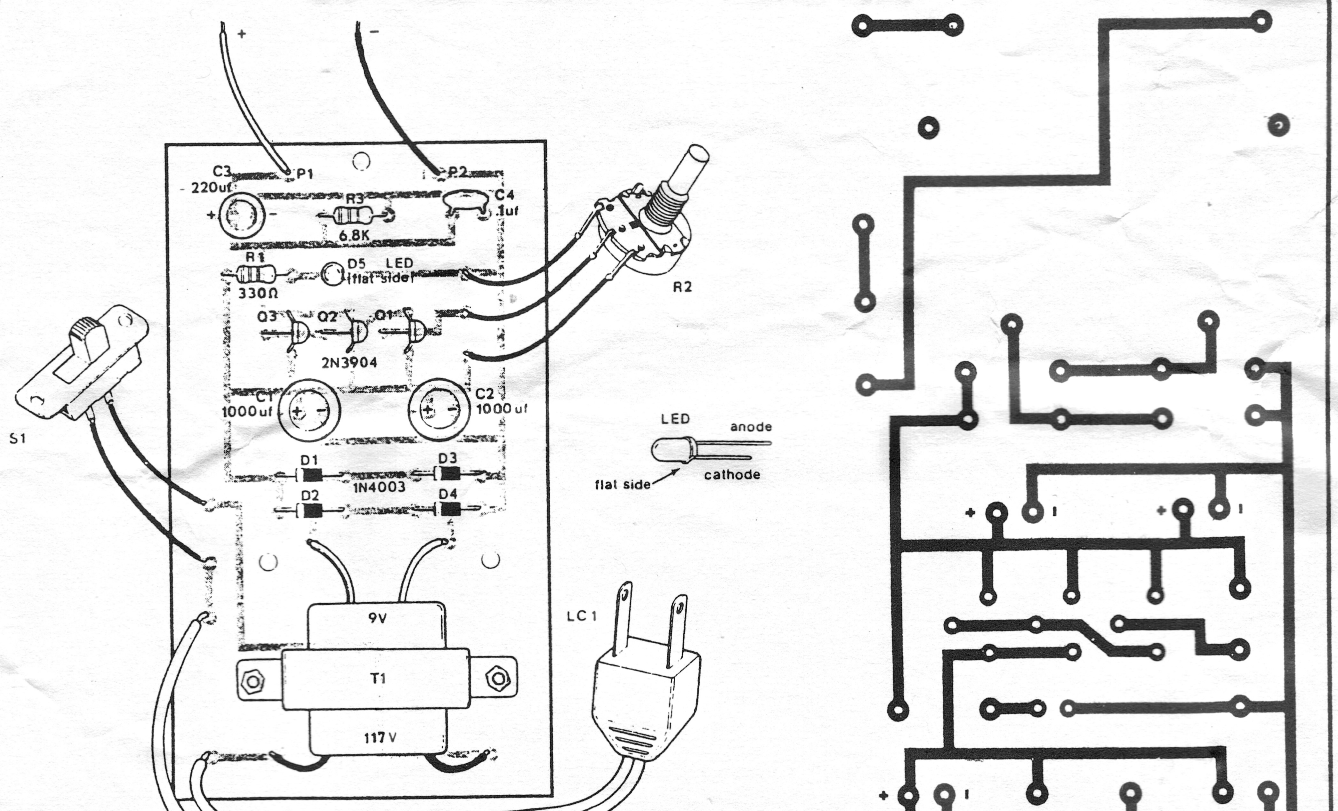
STEP 2. Examining The Solder Connections.
With any project one of the most frequently occuring problems is the existance of poor or "cold" solder connections. Examine each solder connection carefully and be sure that all are nice and shiny. Resolder any that are not. Also look to see if any solder bridge has formed. If they have, break or cut them with cutters or soldering iron.

STEP 3. Looking For Incorrect Parts Placement.
Another major problem in the construction of any electronic project is the misplacement of components or parts. You must be sure that:

-The correct components are in the correct location.

-The components that have polarity such as diodes, transistors, electrolitic capacitors etc., are installed in the correct direction.

PICTORIAL DIAGRAM & CIRCUIT BOARD



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